EFFECTS OF NANO- AND MICRO-CRYSTALLINE SEEDS ON THE GROWTH OF NANO- AND MICRO-CRYSTALLINE DIAMOND THIN FILMS

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Abstract

The early growth stages are critical for the adhesion and final structure of diamond films synthesized by chemical vapor deposition (CVD). We report on the effect of molybdenum substrate seeding with ultra dispersed nano-crystalline diamond and micro-crystalline diamond powders on the nucleation process, growth and structure of hot filament chemical vapor deposited nano- and micro-crystalline diamond, n-D and μ-D, respectively. For each powder used as seeds, diamond thin films were grown for 1, 5, 10 and 20 hours using the same process parameters. Raman spectroscopy (RS), X-ray diffraction analysis (XRD), X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM), and atomic force microscopy (AFM) were performed to study the nucleation process, film nano-structure and diamond quality.

The results show that the nucleation increases as the seed particle size decreases (Figure 1). When nano-crystalline powder is used as seeds, the resulting diamond film is densely clustered, showing both micro and submicro crystallites, whereas when micro-crystalline powder is employed, the resulting film is micro-crystalline and well faceted (Figure 2). All types of seeds lead to high quality (>97%) diamond films growth according to the Raman spectra, although quantitative analysis shows a slightly lower (by ~3 %) diamond film quality when nanocrystalline seeds are employed (Figure 3). Moreover, X-ray diffraction patterns indicate that the seed particle type also affects the film texture. Microcrystalline diamond seeds yield high (111) texture, while the nanocrystalline diamond seeds yield high (400) texture (Figure 4).

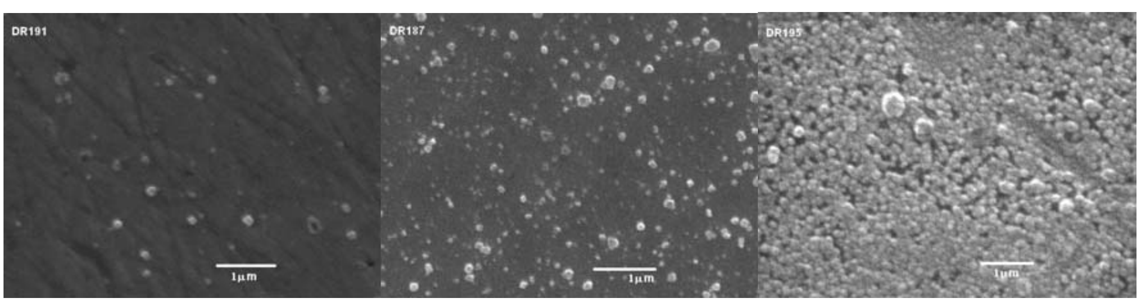

Figure 1. SEM pictures of films deposited after 1 hour using different powders as seeds: (left) high-quality micro-crystalline diamond (from Dr. P. Feng, China); (middle) sub micro-crystalline diamond (from Alfa Aesar); (right) detonation ultra-dispersed nano-crystalline diamond (UDD from Nanodiamond).

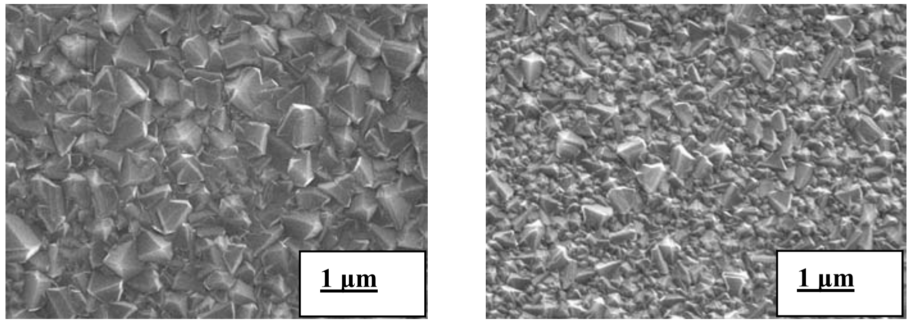

Figure 2. SEM of films deposited after 10 hour using different powders as seeds: (a) high-quality micro-crystalline diamond;(b) detonation ultra-dispersed nano-crystalline diamond).

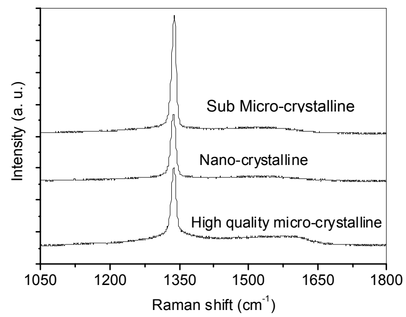

Figure 3. Visible Raman spectra of films deposited after 20 hours using different powders as seeds (sub micro-crystalline, nano-crystalline and high-quality micro-crystalline).

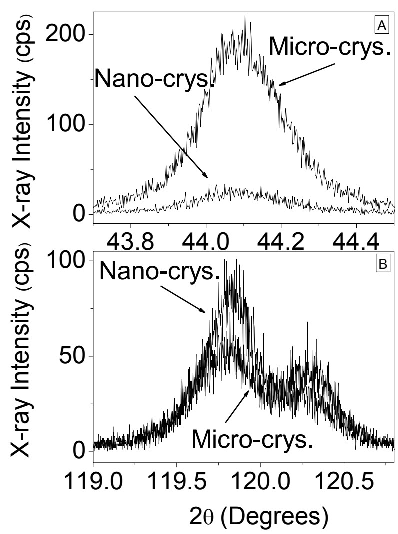

Figure 4. X-ray diffractograms of films deposited after 20 hours using different powders as seeds (micro-crystalline from Alfa Aesar, and nano-crystalline from NanoDiamond), depicting the characteristic diamond peaks corresponding to the (111) (A) and (400) (B) diamond reflections.

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